

ATTACHMENT 1

Inflammable gas or vapour	Experimental maximum safe gap	
	mm	in.
Methane .....	1.170	0.046
Blast furnace gas .....	1.193	0.047
Propane .....	0.965	0.038
Butane .....	1.066	0.042
Pentane .....	1.016	0.040
Hexane .....	0.965	0.038
Heptane .....	0.965	0.038
Iso-octane .....	1.040	0.041
Decane .....	1.016	0.040
Benzene .....	0.99	0.039
Xylene .....	1.066	0.042
Cyclohexane .....	0.94	0.037
Acetone .....	1.016	0.040
Ethylene .....	0.71	0.028
Methyl-ethyl-ketone .....	1.016	0.040
Carbon monoxide .....	0.915	0.036
Methyl-acetate .....	0.990	0.039
Ethyl-acetate .....	1.04	0.041
Propyl-acetate .....	1.04	0.041
Butyl-acetate .....	1.016	0.040
Amyl-acetate .....	0.99	0.039
Methyl alcohol .....	0.915	0.036
Ethyl alcohol .....	1.016	0.040
Iso-butyl-alcohol .....	0.965	0.038
Butyl-alcohol (Normal) .....	0.94	0.037
Amyl-alcohol .....	0.99	0.039
Ethyl-ether .....	0.864	0.034
Coal gas (H <sub>2</sub> 57%) .....	0.482	0.019
Acetylene .....	≤0.025	≤0.001
Carbon disulphide .....	0.203	0.008
Hydrogen .....	0.102	0.004
Blue water gas (H <sub>2</sub> 53% CO 47%) .....	0.203	0.008
Ethyl nitrate .....	≤0.025	≤0.001
Ammonia .....	<sup>1</sup> 3.33	<sup>1</sup> 0.133
Ethylene oxide .....	0.65	0.026
Ethyl nitrite .....	0.922	0.038

<sup>1</sup> Approximately.

[CGD 88–102, 55 FR 25435, June 21, 1990; 55 FR 39270, Sept. 26, 1990, as amended by CGD 96–026, 61 FR 33666, June 28, 1996; USCG–1999–5832, 64 FR 34715, June 29, 1999; USCG–2000–7223, 65 FR 40058, June 29, 2000; USCG–2010–0351, 75 FR 36284, June 25, 2010]

#### APPENDIX B TO PART 154—STANDARD SPECIFICATION FOR TANK VENT FLAME ARRESTERS

##### 1. Scope

1.1 This standard provides the minimum requirements for design, construction, performance and testing of tank vent flame arresters.

##### 2. Intent

2.1 This standard is intended for flame arresters protecting systems containing vapors of flammable or combustible liquids with a flashpoint that does not exceed 60 °C. The test media defined in 14.1.1 can be used except where arresters protect systems handling vapors with a maximum experimental safe gap (MESG) below 0.9 millimeters. Flame arresters protecting such systems must be tested with appropriate media (the

same vapor or a media having a MESG no greater than the vapor). Various gases and their respective MESG are listed in Attachment 1.

NOTE: Flame arresters meeting this standard also comply with the minimum requirements of the International Maritime Organization, Maritime Safety Committee Circular No. 373 (MSC/Circ. 373/Rev. 1).

##### 3. Applicable Documents

3.1 ASTM Standards<sup>1</sup> F722 Welded Joints for Shipboard Piping Systems; F1155 Standard Practice for Selection and Application of Piping System Materials

3.2 ANSI Standards<sup>2</sup> B16.5 Pipe Flanges and Flanged Fittings.

##### 3.3 Other Documents

3.3.1 ASME Boiler and Pressure Vessel Code<sup>2</sup> section VIII, Division 1, Pressure Vessels; section IX, Welding and Brazing Qualifications.

3.3.2 International Maritime Organization, Maritime Safety Committee<sup>3</sup> MSC/Circ. 373/Rev. 1—Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers.

3.3.3 International Electrotechnical Commission<sup>4</sup> Publication 79.1—Electrical Apparatus for Explosive Gas Atmospheres.

##### 4. Terminology

4.1 Flame arrester—A device to prevent the passage of flame in accordance with a specified performance standard. Its flame arresting element is based on the principle of quenching.

4.2 Flame speed—The speed at which a flame propagates along a pipe or other system.

4.3 Flame Passage—The transmission of a flame through a flame arrester.

4.4 Gasoline Vapors—A non-leaded petroleum distillate consisting essentially of aliphatic hydrocarbon compounds with a boiling range approximating 65 °C/75 °C.

##### 5. Classification

5.1 The two types of flame arresters covered in this specification are classified as follows:

5.1.1 Type I—Flame arresters acceptable for end-of-line applications.

5.1.2 Type II—Flame arresters acceptable for in-line applications.

##### 6. Ordering Information

6.1 Orders for flame arresters under this specification shall include the following information as applicable:

6.1.1 Type (I or II).

6.1.2 Nominal pipe size.

6.1.3 Each gas or vapor in the tank being protected by the flame arrester, and the corresponding MESG.

<sup>1</sup>Footnotes appear at the end of this article.

6.1.4 Inspection and tests other than specified by this standard.

6.1.5 Anticipated ambient air temperature range.

6.1.6 Purchaser's inspection requirements (see section 10.1).

6.1.7 Description of installation (distance and configuration of pipe between the arrester, and the atmosphere or potential ignition source) (see section 9.2.4.2).

6.1.8 Materials of construction (see section 7).

6.1.9 Maximum flow rate and the design pressure drop for that maximum flow rate.

#### 7. Materials

7.1 The flame arrester housing, and other parts or bolting used for pressure retention, shall be constructed of materials listed in ASTM F 1155 (incorporated by reference, see §154.106), or section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

7.1.1 Arresters, elements, gaskets, and seals must be of materials resistant to attack by seawater and the liquids and vapors contained in the tank being protected (see section 6.1.3).

7.2 Nonmetallic materials, other than gaskets and seals, shall not be used in the construction of pressure retaining components of the flame arrester.

7.2.1 Nonmetallic gaskets and seals shall be non-combustible and suitable for the service intended.

7.3 Bolting materials, other than that of Section 7.1, shall be at least equal to those listed in Table 1 of ANSI B16.5.

7.4 The possibility of galvanic corrosion shall be considered in the selection of materials.

7.5 All other parts shall be constructed of materials suitable for the service intended.

#### 8. Other Requirements

8.1 Flame arrester housings shall be gas tight to prevent the escape of vapors.

8.2 Flame arrester elements shall fit in the housing in a manner that will insure tightness of metal-to-metal contacts in such a way that flame cannot pass between the element and the housing.

8.2.1 The net free area through flame arrester elements shall be at least 1.5 times the cross-sectional area of the arrester inlet.

8.3 Housings and elements shall be of substantial construction and designed for the mechanical and other loads intended during service. In addition, they shall be capable of withstanding the maximum and minimum pressures and temperatures to which the device may be exposed under both normal and the specified fire test conditions in section 14.

8.4 Threaded or flanged pipe connections shall comply with the applicable B16 standards in ASTM F 1155 (incorporated by reference, see §154.106). Welded joints shall comply with ASTM F 722 (incorporated by reference, see §154.106).

8.5 All flat joints of the housing shall be machined true and shall provide for a joint having adequate metal-to-metal contact.

8.6 Where welded construction is used for pressure retaining components, welded joint design details, welding and non-destructive testing shall be in accordance with section VIII, Division 1, of the ASME Code and ASTM F 722 (incorporated by reference, see §154.106). Welders and weld procedures shall be qualified in accordance with section IX of the ASME Code.

8.7 The design of flame arresters shall allow for ease of inspection and removal of internal elements for replacement, cleaning or repair without removal of the entire device from the system.

8.8 Flame arresters shall allow for efficient drainage of condensate without impairing their efficiency to prevent the passage of flame.

8.9 All fastenings shall be protected against loosening.

8.10 Flame arresters shall be designed and constructed to minimize the effect of fouling under normal operating conditions.

8.11 Flame arresters shall be capable of operating over the full range of ambient air temperatures anticipated.

8.12 End-of-line flame arresters shall be so constructed as to direct the efflux vertically upward.

8.13 Flame arresters shall be of first class workmanship and free from imperfections which may affect their intended purpose.

8.14 Tank vent flame arresters shall show no flame passage when subjected to the tests in 9.2.4.

#### 9. Prototype Tests

9.1 Tests shall be conducted by an independent laboratory capable of performing the tests. The manufacturer, in choosing a laboratory, accepts that it is a qualified independent laboratory by determining that it has (or has access to) the apparatus, facilities, personnel, and calibrated instruments that are necessary to test flame arresters in accordance with this standard.

9.1.1 A test report shall be prepared by the laboratory which shall include:

9.1.1.1 Detailed drawings of the flame arrester and its components (including a parts list identifying the materials of construction).

9.1.1.2 Types of tests conducted and results obtained.

9.1.1.3 Specific advice on approved attachments (see section 9.2.4.1).

9.1.1.4 Types of gases or vapors for which the flame arrester is approved (see section 6.1.3).

9.1.1.5 Drawings of the test rig.

9.1.1.6 Record of all markings found on the tested flame arrester.

9.1.1.7 A report number.

9.2 One of each model Type I and Type II flame arrester shall be tested. Where approval of more than one size of a flame arrester model is desired, the largest and smallest sizes shall be tested. A change of design, material, or construction which may affect the corrosion resistance, endurance burn, or flashback capabilities of the flame arrester shall be considered a change of model for the purpose of this paragraph.

9.2.1 The flame arrester shall have the same dimensions, configuration, and the most unfavorable clearances expected in production units.

9.2.2 A corrosion test shall be conducted. In this test, a complete arrester, including a section of pipe similar to that to which it will be fitted, shall be exposed to a 20% sodium chloride solution spray at a temperature of 25 degrees C for a period of 240 hours, and allowed to dry for 48 hours. Following this exposure, all movable parts shall operate properly and there shall be no corrosion deposits which cannot be washed off.

9.2.3 Performance characteristics as declared by the manufacturer, such as flow rates under both positive and negative pressure, operating sensitivity, flow resistance, and velocity, shall be demonstrated by appropriate tests.

9.2.4 Tank vent flame arresters shall be tested for endurance burn and flashback in accordance with the test procedures in section 14. The following constraints apply:

9.2.4.1 Where a Type I flame arrester is provided with cowls, weather hoods and deflectors, etc., it shall be tested in each configuration in which it is provided.

9.2.4.2 Type II arresters shall be specifically tested with the inclusion of all pipes, tees, bends, cowls, weather hoods, etc., which may be fitted between the arrester and the atmosphere.

9.2.5 Devices which are provided with a heating arrangement shall pass the required tests at the heated temperature.

9.2.6 After all tests are completed, the device shall be disassembled and examined, and no part of the device shall be damaged or show permanent deformation.

#### 10. Inspection

10.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to assure that the material is being furnished in accordance with this standard. All examinations and inspections shall be made at the place of manufacture, unless otherwise agreed upon.

10.2 Each finished flame arrester shall be visually and dimensionally checked to ensure that the device corresponds to this standard, is certified in accordance with section 11 and is marked in accordance with section 12. Special attention shall be given to checking the proper fit-up of joints (see sections 8.5 and 8.6)

#### 11. Certification

11.1 Manufacturer's certification that a flame arrester has been constructed in accordance with this standard shall be provided in an instruction manual. The manual shall include as applicable:

11.1.1 Installation instructions and a description of all configurations tested (reference paragraph 9.2.4.1 and 9.2.4.2). Installation instructions to include manufacturer's recommended limitations based on all configurations tested.

11.1.2 Operating instructions.

11.1.3 Maintenance requirements.

11.1.3.1 Instructions on how to determine when flame arrester cleaning is required and the method of cleaning.

11.1.4 Copy of test report (see section 9.1.1).

11.1.5 Flow test data, including flow rates under both positive and negative pressures, operating sensitivity, flow resistance, and velocity.

11.1.6 The ambient air temperature range over which the device will effectively prevent the passage of flame. (NOTE: Other factors such as condensation and freezing of vapors should be evaluated at the time of equipment specification.)

#### 12. Marking

12.1 Each flame arrester shall be permanently marked indicating:

12.1.1 Manufacturer's name or trademark.

12.1.2 Style, type, model or other manufacturer's designation for the flame arrester.

12.1.3 Size of the inlet and outlet.

12.1.4 Type of device (Type I or II).

12.1.5 Direction of flow through the flame arrester.

12.1.6 Test laboratory and report number.

12.1.7 Lowest MESH of gases for which the flame arrester is suitable for.

12.1.8 Ambient air operating temperature range.

12.1.9 ASTM designation of this standard.

#### 13. Quality Assurance

13.1 Flame arresters shall be designed, manufactured and tested in a manner that ensures they meet the characteristics of the unit tested in accordance with this standard.

13.2 The flame arrester manufacturer shall maintain the quality of the flame arresters that are designed, tested and marked in accordance with this standard. At no time shall a flame arrester be sold with this standard designation that does not meet the requirements herein.

#### 14. Test Procedures for Flame Arresters

##### 14.1 Media/Air Mixtures

14.1.1 For vapors from flammable or combustible liquids with a MESH greater than or equal to 0.9 mm, technical grade hexane or gasoline vapors shall be used for all tests in this section except technical grade propane may be used for the flashback test in Section 14.2. For vapors with a MESH less than 0.9 mm, the specific vapor (or alternatively, a media with a MESH less than or equal to the

MESG of the vapor) must be used as the test medium in all section 14 tests.

14.1.2 Hexane, propane, gasoline and chemical vapors shall be mixed with air to form the most easily ignitable mixture.<sup>5</sup>

14.2 *Flashback Test*

14.2.1 A flashback test shall be carried out as follows:

14.2.1.1 The test rig shall consist of an apparatus producing an explosive mixture, a small tank with a diaphragm, a prototype of the flame arrester, a plastic bag<sup>6</sup> and a firing source in three positions (see Figure 1).<sup>7</sup>

14.2.1.2 The tank, flame arrester assembly and the plastic bag enveloping the prototype flame arrester shall be filled so that this volume contains the most easily ignitable vapor/air mixture.<sup>8</sup> The concentration of the mixture should be verified by appropriate testing of the gas composition in the plastic bag. Three ignition sources shall be installed along the axis of the bag, one close to the flame arrester, another as far away as possible therefrom, and the third at the midpoint between these two. These three sources shall be fired in succession, one during each of the three tests. Flame passage shall not occur during this test.

14.2.1.3 If flame passage occurs, the tank diaphragm will burst and this will be audible and visible to the operator by the emission of a flame. Flame, heat and pressure sensors may be used as an alternative to a bursting diaphragm.

14.3 *Endurance Burn Test*

14.3.1 An endurance burning test shall be carried out as follows:

14.3.1.1 The test rig as referred to in 14.2 may be used, without the plastic bag. The flame arrester shall be so installed that the mixture emission is vertical. In this position the mixture shall be ignited.

14.3.1.2 Endurance burning shall be achieved by using the most easily ignitable test vapor/air mixture with the aid of a pilot flame or a spark igniter at the outlet. By varying the proportions of the flammable mixture and the flow rate, the arrester shall be heated until the highest obtainable tem-

perature on the cargo tank side of the arrester is reached. The highest attainable temperature may be considered to have been reached when the rate of rise of temperature does not exceed 0.5 °C per minute over a ten minute period. This temperature shall be maintained for a period of ten minutes, after which the flow shall be stopped and the conditions observed. If difficulty arises in establishing the highest attainable temperature, the following criteria shall apply. When the temperature appears to be approaching the maximum temperature, using the most severe conditions of flammable mixtures and flow rate, but increases at a rate in excess of 0.5 °C per minute over a ten minute period, endurance burning shall be continued for a period of two hours after which the flow shall be stopped and the conditions observed. Flame passage shall not occur during this test.

<sup>1</sup>American Society for Testing and Materials (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

<sup>2</sup>Available from the American Society of Mechanical Engineers International, Three Park Avenue, New York, NY 10016-5990.

<sup>3</sup>Available from the International Maritime Organization, 4 Albert Embankment, London SE1 7SR, England.

<sup>4</sup>Available from the International Electrotechnical Commission, 1 rue de Varembe, Geneva, Switzerland

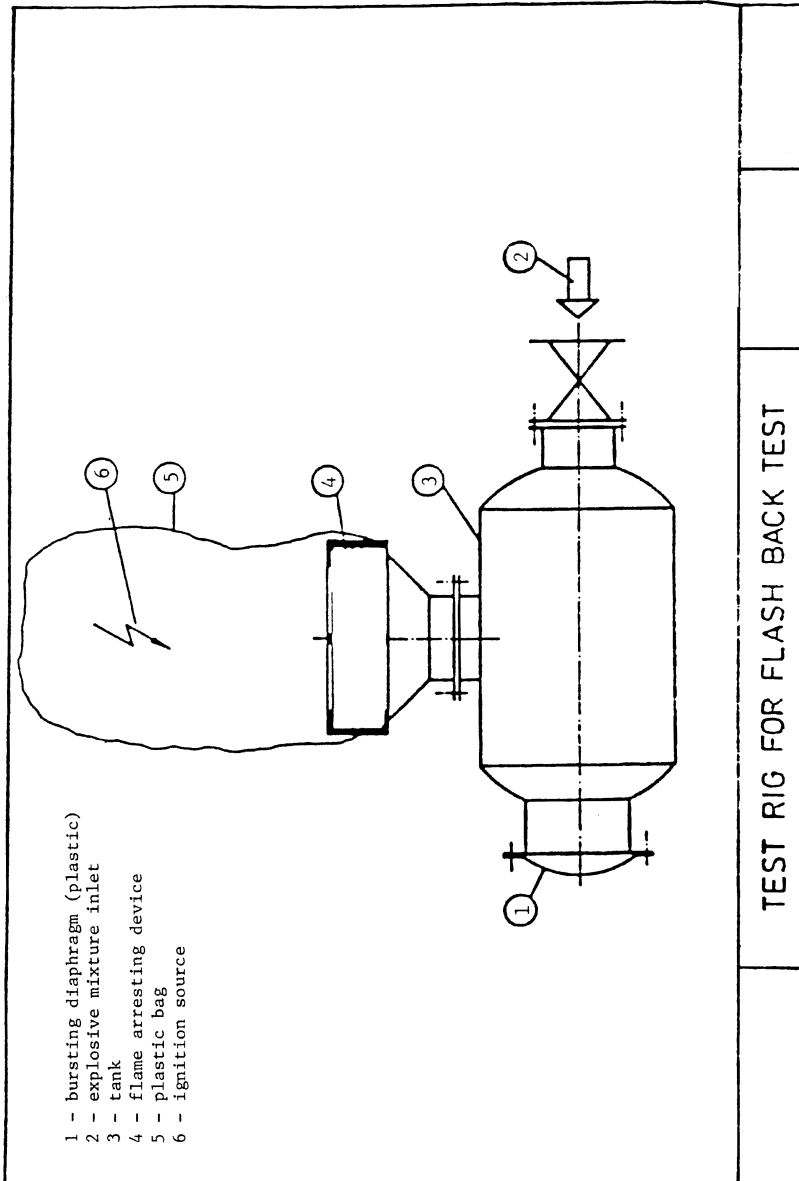
<sup>5</sup>See IEC Publication 79-1.

<sup>6</sup>The dimensions of the plastic bag are dependent on those of the flame arrester. The plastic bag may have a circumference of 2 m, a length of 2.5 m and a wall thickness of .05 m.

<sup>7</sup>In order to avoid remnants of the plastic bag from falling back on to the flame arrester being tested after ignition of the fuel/air mixture, it may be useful to mount a coarse wire frame across the flame arrester within the plastic bag. The frame should be constructed so as not to interfere with the test result.

<sup>8</sup>See IEC Publication 79-1.

FIGURE 1



## ATTACHMENT 1

Inflammable gas or vapor	Experimental maximum safe gap	
	mm	in.
Methane .....	1.170	0.046
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Heptane .....	0.965	0.038
Iso-octane .....	1.040	0.041
Decane .....	1.016	0.040
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Xylene .....	1.066	0.042
Cyclohexane .....	0.94	0.037
Acetone .....	1.016	0.040
Ethylene .....	0.71	0.028
Methyl-ethyl-ketone .....	1.016	0.040
Carbon monoxide .....	0.915	0.036
Methyl-acetate .....	0.990	0.039
Ethyl-acetate .....	1.04	0.041
Propyl-acetate .....	1.04	0.041
Butyl-acetate .....	1.016	0.040
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Methyl alcohol .....	0.915	0.036
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Iso-butyl-alcohol .....	0.965	0.038
Butyl-alcohol (Normal) .....	0.94	0.037
Amyl-alcohol .....	0.99	0.039
Ethyl-ether .....	0.864	0.034
Coal gas (H <sub>2</sub> 57%) .....	0.482	0.019
Acetylene .....	<0.025	<0.001
Carbon disulphide .....	0.203	0.008
Hydrogen .....	0.102	0.004
Blue water gas (H <sub>2</sub> 53% CO 47%) .....	0.203	0.008
Ethyl nitrate .....	<0.025	<0.001
Ammonia .....	13.33	10.133
Ethylene oxide .....	0.65	0.026
Ethyl nitrite .....	0.922	0.038

<sup>1</sup>Approximately.

[CGD 88-102, 55 FR 25441, June 21, 1990, as amended by USCG-1999-5832, 64 FR 34715, June 29, 1999; USCG-2000-7223, 65 FR 40058, June 29, 2000]

## APPENDIX C TO PART 154—GUIDELINES FOR DETERMINING AND EVALUATING REQUIRED RESPONSE RESOURCES FOR FACILITY RESPONSE PLANS

### 1. Purpose

1.1 The purpose of this appendix is to describe the procedures for identifying response resources to meet the requirements of subpart F of this part. These guidelines will be used by the facility owner or operator in preparing the response plan and by the Captain of the Port (COTP) when reviewing them. Response resources identified in subparts H and I of this part should be selected using the guidelines in section 2 and Table 1 of this appendix.

### 2. Equipment Operability and Readiness

2.1 All equipment identified in a response plan must be designed to operate in the con-

ditions expected in the facility's geographic area. These conditions vary widely based on location and season. Therefore, it is difficult to identify a single stockpile of response equipment that will function effectively in each geographic location.

2.2 Facilities handling, storing, or transporting oil in more than one operating environment as indicated in Table 1 of this appendix must identify equipment capable of successfully functioning in each operating environment.

2.3 When identifying equipment for response plan credit, a facility owner or operator must consider the inherent limitations in the operability of equipment components and response systems. The criteria in Table 1 of this appendix should be used for evaluating the operability in a given environment. These criteria reflect the general conditions in certain operating areas.

2.3.1 The Coast Guard may require documentation that the boom identified in a response plan meets the criteria in Table 1. Absent acceptable documentation, the Coast Guard may require that the boom be tested to demonstrate that it meets the criteria in Table 1. Testing must be in accordance with ASTM F 715 (incorporated by reference, see §154.106), or other tests approved by the Coast Guard.

2.4 Table 1 of this appendix lists criteria for oil recovery devices and boom. All other equipment necessary to sustain or support response operations in the specified operating environment must be designed to function in the same conditions. For example, boats which deploy or support skimmers or boom must be capable of being safely operated in the significant wave heights listed for the applicable operating environment.

2.5 A facility owner or operator must refer to the applicable local contingency plan or ACP, as appropriate, to determine if ice, debris, and weather-related visibility are significant factors in evaluating the operability of equipment. The local contingency plan or ACP will also identify the average temperature ranges expected in the facility's operating area. All equipment identified in a response plan must be designed to operate within those conditions or ranges.

2.6 The requirements of subparts F, G, H and I of this part establish response resource mobilization and response times. The distance of the facility from the storage location of the response resources must be used to determine whether the resources can arrive on scene within the stated time. A facility owner or operator shall include the time for notification, mobilization, and travel time of response resources identified to meet the maximum most probable discharge and Tier 1 worst case discharge response time requirements. For subparts F and G, tier 2 and 3 response resources must be notified and